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STRUCTURAL SHAPE FOR USE IN FRAME CONSTRUCTION

BACKGROUND OF THE INVENTION

This is a continuation of Serial No. 08/950,343, October 14, 1997, Patent No. 5,865,008. This invention relates to roof trusses used in the construction industry to frame residential and light commercial buildings. More particularly, this invention is directed to the chord sections that are used to assemble roof trusses used in lightweight steel frame construction.

Wood is the predominant framing material used in residential and light commercial construction in the United States, However, builders, plagued by volatile and rising wood prices and poor quality as timber supplies shrink, continue to seek alternatives. Recent studies have identified steel as a promising alternative framing material to wood.

Various attempts have been made in the past to introduce lightweight, non-wood framing materials into the marketplace. These attempts include advanced composite materials such as fiber-reinforced plastic, as well as lightweight steel components such as doors, windows, siding and framing. However, history shows that whenever a new material becomes available to the construction industry, it is adopted cautiously, initially in small scale applications. Therefore, many of the newer wood substitute materials are not yet in wide use within the building industry. For example, in the instance of residential steel framing, acceptance has been slow because many builders have attempted to assemble lightweight steel framing using traditional wood construction techniques. Such wood construction methods drive up labor costs when applied to steel frame construction and make steel framing non-competitive with conventional wood frame construction. As a result, steel frame construction has gained only a small share of the home building marketplace as compared to wood frame homes. Steel frame construction tends to be concentrated mainly in areas where homes need to meet stricter structural demands to withstand natural phenomena such as earthquakes, high hurricane force winds, and pest problems such as termites.

However, with the adoption of new building techniques that include, for example, prefabricated steel frame panels delivered assembled to the construction site, and with the

availability of new screw guns and fasteners that facilitate and improve steel frame connections, residential steel framing is gaining in popularity within the building industry. In particular, residential roof framing is one area that currently offers improved opportunities for using wood substitute construction materials. Manufactures have introduced an array of different non-wood roof framing products that range from steel roof panels, rafters and purlins, to prefabricated lightweight steel frame roof trusses designed to carry heavy loads over long spans.

The state-of-the-art for non-wood roof truss designs, is dynamic. Numerous different steel truss design improvements have taken place over a relatively short period of time, with many of these improvements directed to the shape of the structural sections used for the top and bottom chord members of the truss. It has been discovered, however, that, past steel truss chord sections present a plethora of problems for roof truss fabricator as well as for home builders.

For example, in Figures 6 and 13 of United States Patent No. 4,435,940 to Davenport, et al., Figures 2 and 5 of U.S. Patent 4,982,545 to Stromback, and in Figures 3 and 6 of U.S. Patent No. 4,986,051 to Meyer, roof truss chord sections are shown comprising outward extending flanges. Such outward extending flanges stiffen and improve the strength of truss chords. However, outward extending flanges prevent the chords from lying flat during shipping and handling, and make it awkward to manufacture the roof truss. Additionally, outward extending flanges expose sharp sheet metal edges, and workers handling such chord sections must exercise extreme caution to avoid serious cuts, lacerations and other injuries.

United States Patent No. 5,463,837 to Dry, teaches forming an outside hemmed edge along both legs of a truss chord. This would tend to protect workers from injury. The radiused hem edge eliminates the sharp edges associated with the outward extending flanges taught in the above three earlier patents. However, tests show that such hemmed edges greatly reduce the roof truss chord section properties to undesirable levels when compared to the outward extending flanges cited above.

Other lightweight steel frame sections teach providing an inward extending flange that maintains good section properties. For example, Figures 1, 3, 5, 7 and 9 of Meyer's United States Patent No. 5,157,883, shows inward extending flanges. The 883 Meyer patent

is directed to vertical studs used in lightweight steel framing. Another example of inward extending flanges, in a roof truss, is shown in Figures 4 and 7 of U.S. Patent No. 4,982,545 granted to Strombach . While such inward extending flange sections would tend to reduce worker injury, maintain good section properties, and allow the sections to lie flat during roof truss fabrication, they create a new set of problems for the truss manufacturer.

A typical roof truss comprises a plurality of web members that extend between the top and bottom chord members of the truss. Each web member is inserted between the legs of the top chord and between the legs of the bottom chord member, and each truss web member is fastened to the chord members using self-drilling sheet metal screws that extend through the chord legs and into the web members or struts. In instances where the truss chord sections include inward extending flanges, prior to the present invention, it has been impossible to use self drilling screws or other simple fasteners to make the necessary truss chord-to-web connections. As clearly shown in the Meyer patent, the inward extending flanges create a large gap or space between the chord legs and inserted web member. Special connection hardware must be used to fasten the truss web members to the top and bottom truss chord members, as illustrated in Figure 9 of Meyer, and such hardware is expensive to produce and time consuming to use.

In an attempt to overcome the aforementioned problems, one truss builder is manufacturing and selling a truss chord section that has inside hems formed along the top edge of both chord legs. The hems are formed with a tight radius in order to be coplanar with a corresponding leg surface that engages the truss web members that are inserted between the legs of the chord section. This roof truss design allows the truss chords to lie flat during roof truss fabrication, eliminates sharp sheet metal edges along the chord legs, and enables fabricators to make truss chord-to-web connections using self-drilling sheet metal screws. However, as stated above for the outside hems, tests show that hemmed edges produce very undesirable section properties in the truss chords. Additionally, in cases where the inside hems become deformed, whether during forming operations or during shipping and handling, deformed hems interfere with inserting the truss web members into the chord sections during fabrication of the roof truss. The chord legs must be pried apart to provide clearance between deformed hems, and this produces a gap between the truss web member and the chord leg that causes the self-drilling screws to fail to seat properly when the truss chord-to-web connections are made. Such defective connections are rejected if

discovered during product quality inspection, or may fail prematurely if used under actual loading conditions.

SUMMARY OF THE INVENTION

Accordingly, it is a first object of the present invention to provide a structural shape comprising a horizontal segment extending between spaced apart legs and having no exposed sharp edges along the length thereof.

Another object of the present invention is to provide a structural shape having no outward projections that prevent the structural shape from lying flat along any one of its outside surfaces.

It is another object of the present invention to provide a truss chord-to-web connection where mechanical fasteners do not extend outside the periphery of the structural shape so that the assembled truss can lie flat along either of its outside surfaces.

It is another object of the present invention to provide a structural shape having inward pointing flanges extending along the spaced apart legs to improve section properties of the structural shape.

It is still another object of the present invention to provide a structural shape where the inward pointing flanges provide clearance for inserting truss web members between the spaced apart legs of the structural section during assembly.

It is still another object of the present invention to provide a structural shape where the inward pointing flanges that extend along the legs of the section facilitate connecting inserted truss web members without special connection hardware.

In satisfaction of the foregoing objects and advantages, the present invention provides a structural section for use in frame construction where the section includes a pair of spaced apart legs. Each leg has a first end portion attached to a horizontal segment, a second end portion opposite the horizontal segment, and a flange that extends or points inward from the second end portion toward the center line of the structural section. Each leg further includes a longitudinal surface located between the first end portion and the second end portion. The longitudinal surface is positioned inboard of the flange so that the distance between the opposed flanges that extend along each leg of the structural section is greater than a the distance between the opposed longitudinal surfaces that extend along each leg of the

structural section.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an end view of the preferred structural shape of the present invention

Figure 1A is a fragmentary view of Figure 1 showing a deformed flange pointing inward from one of the legs.

Figure 2 is an elevation view showing an exemplary roof truss manufactured using the structural shape of Figure 1 as top and bottom roof truss chords.

Figure 3 is a partial end view of the present invention showing an alternate flange embodiment.

Figure 4 is a partial end view of the present invention showing a second alternate flange embodiment.

Figure 5 is a partial end view of the present invention showing a third alternate flange embodiment.

Figure 6 is an end view of a prior art roof truss chord having inside hemmed legs.

Figure 7 is an end view similar to Figure 6 showing deformed inside leg hems.

Figure 8 is an enlarged view of Figure 7.

Figure 9 is a view of the roof truss chord in Figure 7 showing a truss web member forced between the deformed leg hems.

Figure 10 is an enlarged view of Figure 9 showing a truss chord-to-web connection.

Figure 11 is an elevation view showing the structural section of the present invention used as a cord member in a floor truss.

Figure 12 is an elevation view showing the structural section of the present invention used as a chord member in a header.

Figure 13 is an elevation view showing the structural section of the present invention used as a track member and a wall stud member in a steel framing system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the end view labeled Prior Art in Figure 6, the figure illustrates an elongated roof truss chord 1 as disclosed in a DALE/INCOR sales brochure entitled VERSA-TRUSS. Roof truss chord 1 includes a horizontal segment 2 and a pair of spaced apart legs 3a and 3b that include hemmed edges 4a and 4b formed along the upper end

length of each leg. The spaced apart legs further include inside surfaces 5a and 5b that are positioned inward from the plane of legs 3a and 3b to engage truss web members 7 that are inserted between the legs 3a and 3b to fabricate a roof truss. The hems 4a and 4b include inside surfaces 6a and 6b that are coplanar with the inside surfaces 5a and 5b.

Distance "D1" between the leg surfaces 5a and 5b corresponds to outside width "W1" of the truss web members 7 that are inserted into the truss chord sections 1 during fabrication of a roof truss. Because the inside hem surfaces 6a and 6b are coplanar with surfaces 5a and 5b, the truss web members 7 would slide between the hems with very little extra effort as they are inserted between the legs of the roof truss chord. This coplanar alignment would permit fabricators to use self-drilling sheet metal screws, rivets, or mechanical clinching to connect the truss web members to the legs 3a and 3b of the chord section during fabrication of a roof truss.

However, small radius hems can be problematic during roll forming and they are often formed mis-shapened during manufacturing as shown in Figures 7 and 8 of the prior art roof truss chord. The drawing figures show that mis-shapened hems 8a and 8b may extend inward, beyond the plane "P" of the inside surfaces 5a and 5b. This is because the forming operation causes the metal to flow inward toward the center of the section as the hem is formed, and any excess metal or deformity is pushed toward the centerline of the rolled section. Hemmed edges can also be damaged and deformed during shipping and handling of a finished section product. In such circumstances, where the hemmed edges are either mis-shapened or deformed, the inside surfaces 9a and 9b are no longer coplanar with plane "P" of the inside surfaces 5a and 5b. This creates a problem for inserting the truss web members 7. It becomes very difficult to insert the truss web members into the truss chord without first prying and bending the chord legs apart as shown by the direction arrows "A" in Figure 7. Such prying and pulling can create a varied assortment of problems during roof truss fabrication.

For example, prefabricated roof trusses are assembled on large layout tables that hold truss chord lengths of 10 feet and longer. It can be difficult to pry and bend chord legs apart to insert truss web members between mis-shapened, or damaged, or deformed hems. Additionally, when the truss web members 7 are finally forced between such hems and seated at their respective positions along the length of the chord, as shown in Figure 9, the misalignment between the hemmed edges and the leg surfaces 5a and 5b creates a gap "G1"

at the truss chord-to-web connection. As a result of this gap, when the self-drilling sheet metal screws 20, or other suitable fasteners are driven through the members to make the truss chord-to-web connection 21, it is impossible to draw the two pieces together, as shown in the enlarged view of a connection in Figure 10, without distorting the chord section. Such poor connections are structurally unsound. On the one hand, for example, if the fasteners fail to close the gap at truss chord-to-web connection, the "open" connection can induce bending forces in the fastener or cause the fastener to tilt. On the other hand, if the fastener is tightened to close the gap at the truss chord-to-web connection, the additional force required to distort the chord section can overload the fastener and weaken the connection. In such cases, overloaded fasteners can either break, or the fasteners can rip or tear through the sheet metal connections and cause structural failure.

Referring now to Figure 1 of the drawings, the preferred embodiment of the present invention overcomes the aforementioned problems by providing a structural section 10 that comprises a horizontal segment 11 and a first leg 12a spaced apart from a second leg 12b. Each leg includes a lower or first end portion 13 attached to horizontal segment 11, an upper or second end portion 14, and a longitudinal surface 15 located between the lower end portion 13 and the upper end portion 14 of each respective leg 12a and 12b. The longitudinal surfaces 15 are positioned inboard of their respective first and second end portions 13 and 14, and the surfaces 15 are spaced apart a distance "D2" equal to the outside dimension "W2" of truss web members or struts 19 that are inserted between the spaced apart legs during assembly operations. This permits the spaced apart longitudinal surfaces 15 to engage the truss web members inserted between the legs 12a and 12b of the structural section.

Each end portion 14 of the structural section 10 comprises a longitudinally extending flange 16 that extends or points inward from the respective legs 12a and 12b toward the centerline of the structural section 10. Each flange includes a flat or planar segment 17 that communicates with its respective leg 12a or 12b and terminates in a downward pointing leg 18 perpendicular to the flat segment 17. Flanges 16 extend inward from legs 12a and 12b to a position that places the downward pointing legs 18 outboard of their respective longitudinal surfaces 15. This provides a gap "G2" between the longitudinal surfaces 15 and their corresponding flanges 16.

As clearly illustrated in Figure 1, the spaced apart distance "D3" between the

opposite flanges 16 is greater than the spaced apart distance "D2" between the opposite longitudinal surfaces 15. This difference in distances provides the gap "G2" that enables structural section 10 to overcome many of the fabrication and fastening problems described above in the prior art shown in Figures 6-10. For example, Figure 1A shows a deformed flange 16b extending along a portion of leg 12b of the preferred embodiment. However, because the predetermined gap "G2" provides a clear space, the deformed flange 16b does not extend past the plane "P1" of longitudinal surface 15. The predetermined gap "G2" extends along the length of the structural section 10 in the event a flange is deformed anywhere along the section length. Therefore, gap "G2" provides a clearance for proper alignment of the truss web member or strut even when the flanges 16 of the chord member become mis-shapened, and the gap also provides for proper seating of fasteners 20 at the truss chord-to-web connections 21, along the full length of the structural section.

Referring once again to Figure 1A, the longitudinal surfaces 15 are spaced inward from the lower and upper end portions 13 and 14 a distance 20a that is greater than the head thickness 20b of the fasteners 20 used to make the truss chord-to-web connection. This arrangement recesses the fasteners below the surface of the section legs 12a and 12b and enables the assembled truss to lie flat during shipping and handling, and protects the fasteners from damage.

It should be understood, however, that although the preferred embodiment shows flanges 16 comprising a planar segment 17 that terminate in a downward point end leg 18, other equivalent inward pointing flange shapes can be used without departing from the scope of this invention. For example, referring to Figure 3, an equivalent structural section 10 is shown including spaced apart flanges 16 that are similar to the flanges of the preferred embodiment. In this case, however, the flat or planar portion 17 terminates in a downward pointing leg 22 that is sloped toward the centerline of the structural section at a position that will provide the necessary gap "G2" for proper alignment and fastening in the event a flange is deformed.

Likewise, a second alternate embodiment is shown in Figure 4 comprising a structural section 10 having spaced flanges 16 similar to the flanges of the preferred embodiment. In this second case the planar portions 17 terminate in downward pointing legs 23 that slope outward away from the centerline of the structural section at a position that provides the necessary gap "G2" for proper alignment and fastening in the event a

flange is deformed.

Similarly, a third equivalent embodiment, shown in Figure 5, comprises a section 10 having spaced flanges 16 comparable to the flanges of the preferred embodiment. In this last example the planar portions 17 terminate in curvilinear legs 24 that are positioned to provide the necessary gap "G2" for proper alignment and fastening in the event a flange is deformed.

Any of the flange arrangements shown in Figure 1 and Figures 3-5, or any other equivalent flange arrangement that provides the necessary gap "G2" is suited for use as a chord section in assembling the exemplary roof truss "T" shown in Figure 2. Roof truss "T" comprises a top and bottom chord section 10a and 10b respectively. Truss web members or struts 19 extend between the top and bottom chord sections and the web members are attached to the chords at the connections 21 as described above.

However, it should be understood that the structural shape of the present invention is not intended to be limited to use in a roof truss. For example, referring to Figure 11, the structural section of the present invention is shown being used as bottom and top chords 25a and 25b in a floor truss. Similarly, in Figure 12, the structural section is shown used as a bottom and top header chord 26a and 26b over a window opening. Figure 13 shows the structural section adapted for use as a framing track 27 and a stud 28 for residential or light commercial framing.

As heretofore disclosed, the inward pointing flanges 16 of the present invention, in combination with the gap "G2," overcomes many of the problems of prior structural sections used in residential framing. For example, in order to insure proper alignment and good truss chord-to-web connections, past designers have provided tight hemmed ends as shown in Figure 6, the Dry patent, and the DALE/INCOR brochure. "Table A" shown below lists data developed during axial compression tests conducted on three different, structural sections. Each section was 3" tall and 1½" wide. The test specimens included a truss chord having a flanged section according to the preferred embodiment of the invention shown in Figure 1, a hemmed section as shown in Figure 6 and the Dry patent, and a simple "U" shaped section (not shown) that comprised a shape having a horizontal segment and two spaced apart legs that had no stiffening means added such as hems or flanges. The simple "U" shaped test sections were formed from 12" x 7½" wide strips of 20 gauge and 22 gauge sheet steel, the hemmed sections were formed from 12" x 8.625" wide strips of 20 and 22 gauge steel, and

the flanged sections were formed using 12" x 9.875" wide strips of 20 and 22 gauge sheet steel. Three 20 gauge sections and three 22 gauge sections were tested for each of the three different shapes, and the tests were conducted in accordance with accepted AISI standard "Stub Column Test Method for Effective Area of Cold Formed Steel Columns."

The test data in "Table A" clearly shows that the inward pointing flanges 16 of the present invention greatly improve section properties over hemmed, state-of-the-art truss chords taught by Dry and Dale. Referring to the test results, the three recorded ultimate loads for each test series were averaged and then divided by linear inches of material used to form the shape to determine the efficiency of the shape (see Average Load (lb.)/Linear inches). It was discovered that the hemmed shape is less efficient than the simple "U" shape having no stiffening hems or flanges. It was also discovered that the flanged shape of the present invention is over two times more efficient than the hemmed shape.

Table A

CHORD SECTION THICKNESS	LOAD (lb.) Simple "U" Shape (7.5")	LOAD (lb.) Hemmed Shape (8.625")	LOAD (lb.) Flanged Shape (9.875")
22 Gauge.(0297")	3300	3550	8500
" "	3300	3450	8500
" "	3400	3800	9000
Average Load (lb.)/ Linear inches	**444**	**417**	**878**
20 Gauge (0.0344")	5200	5700	14700
" "	5250	5400	13100
" "	5350	5400	13800
Average Load (lb.)/ Linear inches	**702**	**638**	**1404**